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THE LAW OF GEMINATE SPECIES

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IN "Evolution and Animal Life," by Jordan and Kellogg (page 120), the following words are used:

> "Given any species, in any region, the nearest related species is not to be found in the same region nor in a remote region, but in a neighboring district separated from the first by a barrier of some sort or at least by a belt of country, the breadth of which gives the effect of a barrier."

Substituting the word "kind" for species in the above sentence, thus including geographical subspecies, or nascent species, as well as species clearly definable as such, Dr. J. A. Allen accepts this proposition as representing a general fact in the relations of the higher animals. To this generalization Dr. Allen, in a late number of *Science*, gives the name of "Jordan's Law." The present writer makes no claim to the discovery of this law. The language above quoted is his, but the idea is familiar to all students of geographical distribution and goes back to the master in that field, Moritz Wagner.

This law rests on the fact that the minor differences which separate species and subspecies among animals are due to some form of segregation or isolation. By some barrier or other the members of one group are prevented from interbreeding with those of another minor group or with the mass of the species. As a result, local peculiarities arise. "Migration holds species true, localization lets them slip,'' or rather leaves them behind in the process of modification. The peculiarities of the parents in an isolated group become intensified by in and in breeding. They become modified in a continuous direction by the selection induced by the local environment. They are possibly changed in one way or another by germinal reactions from impact of environment. At last a new form is recognizable. And this new form is never coincident in its range with the parent species, or with any other closely cognate form, neither is it likely to be in some remote part of the earth. Whenever the range of two such forms overlaps in any degree, the fact seems to find an explanation in reinvasion on the part of one or both of the forms. The obvious immediate element in the formation of species is, therefore, isolation, and behind these are the factors of heredity, of variation, of selection, and others as yet more or less hypothetical involved in the effect of impact of environment on the germ cells themselves. The formation of breeds of sheep as noted by Jordan and Kellogg (p. 82), seems exactly parallel with the formation of species in nature. In like manner, the occasional development of breeds arising from the peculiarities of individuals is possibly parallel with the ''mutations'' of the evening primrose. Such breeds are the Ancon sheep in Connecticut and the blue-cap Wensleydale[1] sheep in Australia. The ontogenetic species—groups in which many individuals are simultaneously modified in the same way by like conditions of food or climate—show no permanence in heredity. Such forms, however strongly marked, should, therefore, have no permanent place in taxonomy. The recent studies of Mr. Beebe on the effects of moist air in giving dusky colors to birds serve to illustrate the impermanence of the groups or subspecies characterized by dark shades of color developed in regions of heavy rainfall.

It may also be noted in passing that one cause of the potency of artificial selection among domesticated animals or cultivated plants is that such selection is always accompanied by segregation. The latter is taken for granted in discussions of this topic and hence its existence as a factor is usually overlooked. While poultry or pigeons can be rapidly and radically changed by artificial selection, in isolation, no process of selection without isolation is likely to have any permanent result. For example, we know no way of improving the breed of salmon, because the salmon we have selected for reproduction must be turned loose in the sea, where they are at once lost in the mass.

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[1] Blue Cap, a ram of Leicester-Teeswater parentage, having a blue shade on his head, was the progenitor of a breed having this peculiarity, known as the Wensleydale, in Australia.

New forms of gold-fish and carp can be made easily in domestication, because these fishes can be kept in aquaria or in little ponds, but new forms of mackerel or herring are beyond the control of man and the species actually existing have been of the slowest creation, their origin lost in geologic times.

One of the most interesting features of "Jordan's law" is the existence of what I may term *geminate* species—twin species—each one representing the other on opposite sides of some form of barrier. In a general way, these geminate species agree with each other in all the respects which usually distinguish species within the same genus. They differ in minor regards, characters which we may safely suppose to be of later origin than the ordinary specific characters in their group. Illustrations of geminate species of birds, of mammals, of fishes, of reptiles, of snails, or of insects, are well known to all students of these groups, and illustrations may be found at every hand.

Each island of the West Indies, which is well separated from its neighbors, has its own form of golden warbler. Each island in the East Indies has its geminate forms of reptiles or fishes. Each island of the Hawaiian group has its own representative of each one of the types or genera of Drepanidæ. Each group of rookeries in Bering Sea has its own species of fur seal.

One of the most remarkable cases of geminate species is that of the fishes on the two sides of the isthmus of Panama. Living under essentially the same conditions, but separated since the end of the Miocene Period by the rise of the isthmus, we find species after species which has been thus split into two. These geminate species, a hundred or more pairs in number, were at first regarded as identical on the two shores of the isthmus. Later one pair after another was split into recognizable species. The latest authority on the subject, Mr. C. T. Regan, seems to doubt if any species of shore fishes are actually identical on the two sides of the isthmus.

To make this clear, though at the risk of being tedious, I give below a partial list of these geminate species about the isthmus of Panama:

Atlantic Coast	Pacific Coast
Harengula humeralis	*Harengula thrissina*
Clupanodon oglinus	*Clupanodon libertatis*
Centropomus undecimalis	*Centropomus viridis*
Centropomus pedimacula	*Centropomus medius*
Centropomus affinis	*Centropomus ensiferus*
Epinephelus adscensionis	*Epinephelus analogus*
Alphestes afer	*Alphestes multiguttatus*
Dermatolepis inermis	*Dermatolepis punctatus*
Hypoplectrus unicolor	*Hypoplectrus lamprurus*
Lutianus cyanopterus	*Lutianus novemfasciatus*
Lutianus apodus	*Lutianus argentiventris*
Lutianus analis	*Lutianus colorado*
Lutianus synagris	*Lutianus guttatus*
Hæmulon album	*Hæmulon sexfasciatum*
Hæmulon parra	*Hæmulon scudderi*
Hæmulon schrancki	*Hæmulon steindachneri*
Anisotremus suriamensis	*Anisotremus interruptus*
Anisotremus virginicus	*Anisotremus tæniatus*
Conodon nobilis	*Conodon serrifer*
Pomadasis crocro	*Pomadasis branicki*
Calamus macrops	*Calamus taurinus*
Xystæma cinereum	*Xystæma simillimum*
Encinostomus pseudogula	*Encinostomus dowi*
Kyphosus incisor	*Kyphosus analogus*
Isopisthus parvipinnis	*Isopisthus remifer*
Nebris microps	*Nebris zestus*
Larimus fasciatus	*Larimus pacificus*

Atlantic Coast	Pacific Coast
Odontoscion dentex	*Odontoscion xanthops*
Corvula sialis	*Corvula macrops,*
Bairdiella veræ-crucis	*Bairdiella armata*
Micropogon furnieri	*Micropogon ectenes*
Umbrina broussoneti	*Umbrina xanti*
Menticirrhus littoralis	*Menticirrhus elongatus*
Eques acuminatus	*Eques viola*

This list may be greatly extended, but the series noted will illustrate the point in question. Whenever a distinct and sharply defined barrier exists, geminate or twin species may be found on the two sides of it, unless, as sometimes happens, the species has failed to maintain itself on one side of the barrier. So far as Panama is concerned, we have evidence that the barrier was raised near the end of Miocene time with no trace of subsequent depression. We can thus form some estimate of the age of separation in at least a small number of closely related species. In this and similar cases it is not possible to conceive of the formation of these species by sudden mutation, or that they would retain their separate existence were the element of segregation removed. While segregation or isolation is not a force, and perhaps not strictly a cause in species formation, it is a factor which apparently can never be absent, if the species retains its independent existence.

There is no doubt that the distribution of higher animals in general is in accord with "Jordan's Law." Examples by the thousand come up from every hand. If we had a hundredth part of the amount of available evidence in support of mutation theories, these theories would pass from the realm of hypothesis into that of fact. But the application of this law or rule to plants and to one-celled animals has been questioned. So far as rhizopods are concerned, Dr. Kofoid finds that the species are in general sharply defined and of the widest distribution in the sea, so that we can hardly state laws as defining their geographical distribution. To these minute floating animals, the sea scarcely offers barriers at all, and the recognized species do not seem to be products of geographical isolation. Doubtless these species in duration and in nature correspond more nearly to genera or families of higher animals than to actual species. Perhaps minor specific differences such as we note among arthropods or vertebrates are intangible or non-existent. The effects of isolation may be tangible only among forms which possess more varied relations with their environment.

The application of this law to plants has also been denied. But geminate species are just as common in botany as in zoology, and the effects of isolation in species-forming are just as distinct. The law is just as patent in the one case as in the other. It is merely obscured by other laws or conditions which obtain among plants.

In the nature of things, most physical barriers are more easily crossed by plants than by animals. The possibilities of reinvasion are thus doubtless much increased. The plant is limited by climate, rainfall, nature of soil, and the same species is likely to occupy all suitable locations within a large area. Animals are more mobile than plants within their range, a fact which tends to keep the interbreeding masses more uniform. In the struggle for existence, the plant is pitted against its environment. Whether a plant survives or not depends not much on the nature of the seed, but mainly on its relation to the spot on which it falls. There is little selection within the species due to the choice of one individual as against another. This can only happen where plants are overcrowded, and there the survival is mainly that of the seed whose roots run deepest. There is little room for struggle between closely related species. Each individual grows—if it can—on the spot where it falls. The variations among plants are great, but these variations are mostly lost unless reinforced by segregation. There is no likelihood of the survival of DeVries' mutants of the evening primrose if these forms are left free to mix in the same field.

Among plants we often notice the fact—rare though not unknown among animals—of numerous species of the same genus occupying the same area. In some cases these species are closely related, suggesting mutants, and in other cases the relation indicates the existence of hybrids. In California, for example, there are in the same general region many species of Lupinus, of Calochortus, of Ceanothus, of Arctostaphylos, of Eschscholtzia, of Godetia, of Œnothera, and Opuntia. Eucalyptus, Acacia and Epacris in Australia are examples even more striking. But I have never seen very closely related or geminate forms in any of these genera actually growing together. I suspect that they do so sometimes and that the explanation is found in reinvasion. But ''growing together'' is an indefinite statement as applied to plants. The elder, the alder and the madroño (arbutus) abound in the Santa Clara Valley. But no one ever saw any two of these trees standing side by side. Each has its limitations, as to soil and moisture.

Setting aside these genera which are represented by many species in a limited area, and among which mutation and hybridism may be conceivably factors in species-forming, we find the law of geminate species applying to plants as well as to animals. Crossing the temperate zone anywhere on east and west lines, we find species after species replaced across the barriers by closely related forms. Illustrations may be taken anywhere among the higher plants—equally well, no doubt, among lower ones. Many genera are local in their distribution, monotypic—with a single species, the origin of which can not be traced. But many other genera belt the earth or come very near doing so, each form or species being geminate as related to its next neighbor. This fact is illustrated in Rubus, Alnus, Sambucus, Platanus, Fagus, Veratrum, Symplocarpus, Symphoricarpus, Castanea, Quercus, Pinus, Tsuga, Acer, Rhus, Pyrus, Prunus, Lonicera, Ranunculus, Trientalis, Lilium, Trillium, Veronica, Aquilegia, Gentiana, Viola, Epilobium, Pteris, Mimulus, Trifolium, Solidago, Aster. All these genera and many others furnish an abundance of examples.

We may, therefore, say that with plants as well as animals geminate species as above defined owe their distinctness to some form of isolation or segregation, and that, broadly speaking, with occasional exceptions, given any form of animal or plant in any region, the nearest related form is not to be found in the same region nor in a remote region, but in a neighboring region, separated from the first by a barrier of some sort, not freely traversable.

A law, that is, an observed relation of cause and effect is not invalidated by the presence of other effects due to other causes, in the same environment. The actual conditions in nature are everywhere not products of single and simple forces, but resultants of many causative influences, often operative through the long course of the ages.

It may be urged that these geminate groups or forms are not true species, because they often intergrade one into another, and they would probably be lost by intermingling if the barriers were removed. It is sometimes claimed that only physiological tests of species can be trusted, as true species will not blend and their hybrids, if formed, will be sterile. All this is purely hypothetical and impracticable to the systematic zoologist, and not of much value to the botanist. Closely related species can usually be readily crossed. As the relation becomes less close, partial sterility of all grades and then total sterility appear.

Species as we find them in nature are real *species* if that term has any definition. And real species have, as a rule, indefinite boundaries, shading off into subspecies, geminate species, ontogenetic forms and the like. And if we are to understand the significance of nature, we have to describe these facts and relations as they actually are. Then we have to find out what changes we can work in individuals and in species by such alterations of conditions as experiment can give.

We do not know actually any species of animal or plant until we know all changes that would take place in its individuals under all conditions of environment.